(Resonant) Hard X-ray Ptychography for High-Sensitivity Imaging with Chemical Contrast

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Abstract

The investigation of innovative materials and chemical processes requires deep insight into their respective morphology and dynamics. Equally important is the knowledge of the chemical distribution in terms of elements and oxidation states. For this purpose, high-resolution X-ray imaging is an important tool in nanoscience to analyse individual features of various kinds of specimens such as heterogeneous catalysts or biological samples.

In recent years, the scanning coherent imaging technique – ptychography – has been established providing high spatial resolution and also element sensitivity [1]. The combination of ptychography with resonant scattering or X-ray fluorescence enables access to both, the morphology and also chemical distribution of the sample. In order to fully exploit the information encoded in the data, a consistent and reliable reconstruction process is essential.

This presentation addresses the challenges in quantitative analysis of ptychographic datasets, especially due to the limited sensitivity to weakly scattering features as well as due to positioning errors. In this context, a beamstop-based double-exposure scheme to improve the sensitivity and the spatial resolution will be presented together with further extensions to the ptychographic reconstruction algorithm [2]. Fig. 1 shows the enhanced image quality based on these modifications.

Furthermore, by giving examples from different fields of research, the possibilities and current limitations of using hard X-ray ptychography for chemical imaging will be illustrated.

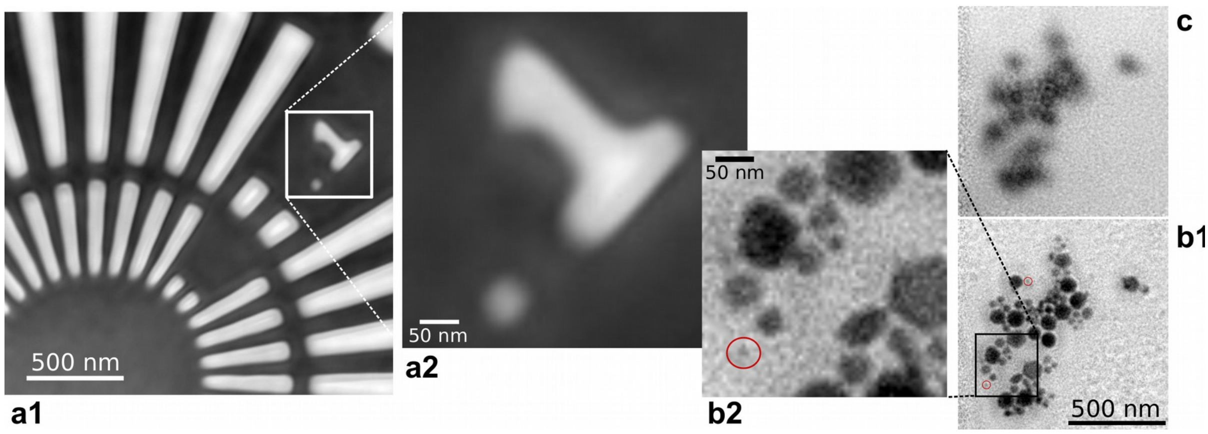

Figure 1: a1) shows a phase reconstruction of a testpattern (NTT-AT) with the smallest feature enlarged in a2) [3]. In comparison, b1) shows a phase reconstruction of nanoparticles in the range of 15 nm to 80 nm in diameter, which are enlarged in b2). The 15 nm sphere in marked by the red circle in b2) scatters 4000 times less than the dot in a2). c) shows the phase reconstruction in conventional ptychography mode without a beamstop dominated by noise and without detailed features.

References

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